REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

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1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	September 2003	USARIEM Technical Report

4. TITLE AND SUBTITLE
Cold Air Data Acquisition System Documentation

5. FUNDING NUMBERS

6. AUTHOR(S)
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8. PERFORMING ORGANIZATION REPORT NUMBER
TN04-04

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Same as #7 above.

10. SPONSORING / MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*
This report describes a data acquisition system developed to obtain body temperature measurements for human volunteers during cold air exposure. Since acceptable commercial systems are not available, we had to custom-build this system to acquire data using National Instruments hardware components and LabVIEW 6.0 Developmental Software. This report provides detailed documentation for the construction and operation of the cold air data acquisition system. This report lends to the reader insight to duplicate or modify this system, given general background knowledge in National Instrument's LabVIEW graphical programming language. General requirements for this system were that it be accurate, precise, lightweight, and portable. The system also needed to be able to function within the environmental temperatures of the protocol. Based on the requirements noted above, the hardware chosen for this system consists of the NI DAQCARD-6036E multifunction A/D/A data acquisition card, SCXI-1000 4-slot chassis, SCXI-1581 analog output/excitation module, SCXI-1102 analog input module, (two) SCXI-1300 32-channel terminal blocks, and appropriate adaptors/cabling to interface it with one of our laptops via PCMCIA port. The software required to manipulate the acquired signals and to build the user interface is the National Instruments LabVIEW 6.0 Development Package. Development of this system is achieved by sampling analog signals, at regular intervals, from thermistors (placed in the air, on the skin, and in the subject's esophagus and rectum) and from user input controls and modifying them within the custom software to obtain real-time measurements. Four-wire heat flow disks (Concept Engineering, Old Saybrook, CT) will be used to acquire skin temperature (Tsk) and heat flow (HF). Voltage will be measured across two (white/black) of the four wires, and resistance will be measured across the other two wires (red/yellow). Finally, data is secured by opening the destination file, appending data to this file, and closing this file each time data are collected. This method ensures that data are not lost during an unlikely power failure or software corruption. Considering that data are collected every 15 seconds, this method of data collection keeps RAM free and does not stress system resources.

14. SUBJECT TERMS
Data Acquisition; National Instruments; Temperature Monitoring; Water Immersion

15. NUMBER OF PAGES
33

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

USARIEM TECHNICAL NOTE TN04-04

COLD AIR DATA ACQUISITION SYSTEM DOCUMENTATION

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SEPTEMBER 2003

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INTRODUCTION

This report describes a data acquisition system developed to obtain body temperature measurements for human volunteers during cold air exposure. Since acceptable commercial systems are not available, we had to custom-build this system to acquire data using National Instruments hardware components and LabVIEW 6.0 Developmental Software. This report provides detailed documentation for the construction and operation of the cold air data acquisition system. This report lends to the reader insight to duplicate or modify this system, given general background knowledge in National Instrument's LabVIEW graphical programming language.

General requirements for this system were that it be accurate, precise, lightweight, and portable. The system also needed to be able to function within the environmental temperatures of the protocol. Based on the requirements noted above, the hardware chosen for this system consists of the NI DAQCARD-6036E multifunction A/D/A data acquisition card, SCXI-1000 4-slot chassis, SCXI-1581 analog output/excitation module, SCXI-1102 analog input module, (two) SCXI-1300 32-channel terminal blocks, and appropriate adaptors/cabling to interface it with one of our laptops via PCMCIA port. The software required to manipulate the acquired signals and to build the user interface is the National Instruments LabVIEW 6.0 Development Package.

Development of this system is achieved by sampling analog signals, at regular intervals, from thermistors (placed in the air, on the skin, and in the subject's esophagus and rectum) and from user input controls and modifying them within the custom software to obtain real-time measurements. Four-wire heat flow disks (Concept Engineering, Old Saybrook, CT) will be used to acquire skin temperature (T_{sk}) and heat flow (HF). Voltage will be measured across two (white/black) of the four wires, and resistance will be measured across the other two wires (red/yellow).

The software Graphical User Interface (GUI) was designed, by this author, to be user-friendly with minimal user input configurations to manage. The testing operator of the system need only enter a filename and subject identification number as preparation for data collection. The interface contains only 3 buttons for the user to deal with (run, stop, and record data). The GUI was designed to provide immediate numerical indication of skin and core temperatures, as well as environmental conditions. The interface was also designed to provide both a graphical history of data, as well as a numerical history in tabular form. Therefore, the last data point can be viewed immediately, a historical table of all data can be scrolled through, and trends in data can be tracked graphically. The interface was required to have start and stop testing buttons and the ability to monitor data or monitor/record data to disk, all clearly marked and easy to locate. The system is designed to run continuously throughout testing, once started, without the need for an operator to constantly monitor the system. Besides the start, stop, and monitor controls, the system was developed with the ability to enter unique file names and enter predetermined "event-markers" to identify various stages of testing.

Finally, data is secured by opening the destination file, appending data to this file, and closing this file each time data are collected. This method ensures that data are not lost during an unlikely power failure or software corruption. Considering that data are collected every 15 seconds, this method of data collection keeps RAM free and does not stress system resources.

MATERIALS

- (1) National Instruments LabVIEW 6.1 developmental software package
- (1) SCXI-1000 4-slot chassis
- (1) SCXI-1581 100μA current excitation analog output module
- (1) SCXI-1102 analog input module
- (2) SCXI-1300 32-channel low-voltage terminal block
- (1) 68-POS series D-type cable assembly (type SHC68-68EP 1m.)
- (1) 68 POS cable adaptor for SCXI-1000 chassis
- (3) SCXI-1361 (rear filler panel)
- (2) SCXI-1360 (front filler panel)
- (1) NI DAQ card-6036E multifunction PCMCIA data acquisition card
- (1) Laptop computer with PCMCIA port
- (1) Fluke 27 Digital Multimeter

METHODS

Measurements

The system acquires skin temperature (T_{sk}) by measuring resistance across the thermistors, individually amplified by a stable excitation current of 100μA. Once amplified on the SCXI-1300 by the SCXI-1581 (located in slot 1), the wires are then "jumped" (physically wired) to the corresponding terminal on the other SCXI-1300 connected to the SCXI-1102 analog input module (located in slot 2). The analog input module (SCXI-1102) then measures the resistance across the two wires (red/yellow). A linearization equation is implemented within the software to convert the measured resistances (Ω) into temperatures (°C) (see Equation 1). A value for the mean weighted skin temperature (MWST) is also implemented within the software using the weighted average of selected heat flow disks (see Equation 2). T_{es}, T_{re}, and T_a are also acquired by thermistors amplified by the SCXI-1581 and measured by the SCXI-1102 module and then linearized by the same equation. Skin temperatures are measured on channels 0-11 and T_c, T_{es}, and T_a are measured on channels 24-26, respectively.

Heat flow is also acquired by measuring the voltage across the remaining two wires (black/white) on the heat flow disks, wired directly into channels 12-23 the SCXI-1300 connected to the SCXI-1102 module. Each heat flow disk has an individual calibration constant, which it is scaled by before it is recorded. The heat flows are configured so that a positive value indicates that the skin is warmer than the ambient temperature and a negative value indicates that the skin is cooler than the ambient temperature.

Programming design

Prior to writing LabVIEW code, each measurement was predetermined within National Instruments Measurement and Automation Explorer (MAX). A "Virtual Channel" was created for each analog input that was to be made. Within MAX, measurement type (resistance/voltage), max/min values, channel position, and resolution were configured, each under unique names. MAX allowed us to quickly and concisely select the desired channel to measure in our "acquire analog input" VI (Virtual Instrument) described below (Figures 3 and 10).

The main portion of the program was built within a "while loop" and, once initiated, will run continuously until the user clicks the stop button, which is a "stop if true" Boolean. Upon activating this button, the activity within the loop will cease, and data will stop being collected. The program collects data, manipulates it as desired, and writes to disk within this main loop. Outside the loop is a VI (Figure 2) that opens a file, obtains an initial time and date stamp, acquires a file name according to the users text input string entry on the Front Panel (Figure 9) (entitled "filename"), writes a series of predetermined "headers" for each spreadsheet column, and then passes this information into the loop that writes these data to the beginning of the spreadsheet. Data collected from this point on append to the end of each row to eliminate the potential for overwriting data.

Upon activation of the "run" button, each "Acq AI" (Figure 3) VI will initialize the hardware and begin sampling (at 15 second intervals) the "Y" value of the waveform being acquired and timestamp each sample simultaneously. The software will acquire a measure of resistance from channels 0-11, 24-26 to obtain temperatures and a measure of voltage for channels 12-23 to obtain heat flows. The measurements are then manipulated by

successive VI's to obtain usable data. Resistance measurements are passed through a linearization equation (Figure 5) to acquire a temperature in degrees Celsius (°C). A VI acquiring a measure of mean weighted skin temperature (MWST) (Figure 11) gathers data collected from selected thermistors (determined by body placement), multiplies each site by a specific percentage of the whole, sums them and then passes the data into the spreadsheet to be written to disk (Equations 1 and 2).

Timestamps are handled by acquiring hours, minutes, and seconds from the CPU clock time and writing them to a spreadsheet in separate columns. A running time is also acquired by taking the absolute value of a "Get Current Time" VI (Figure 1) VI and subtracting the time acquired at zero.

A simple event marker is placed on the front panel, with selectable values from 0-5 indicating phases of testing. The control will write the number to each row. The values indicate the following phases: 0 = Start data collection; 1 = Baseline; 2 = Start cognitive test; 3 = Start MRPM; 4 = Start bike test; 5 = End test.

Once the program is initiated, the user has the option to monitor or collect the data being displayed. This was performed by placing the "write to disk" VI (Figure 1) within a while loop controlled by a "continue if true" Boolean button on the front panel.

All data collected are displayed on the front panel in table format, with the last four samples collected in continuous view. The table contains vertical and horizontal scrollbars to view the entire data set collected. The table "headers" are linked to the VI "build header" (Figure 2) via property node and will update each column if the "build array" function within "write header" is altered. The spreadsheet column titles are listed in table 3 (see also Figure 2).

Physical connections/wiring

The temperature wires 0-11 (red/yellow) for each heat flow disk are connected to channels 0-11 on the 100μA amplified SCXI-1581 terminal block. "Jumpers" (pairs of insulated 18 AWG wire) are then connected from those terminals to the corresponding channels on the SCXI-1102 module, and a measure of resistance across the two wires is taken. T_{re}, T_{es}, and T_a are also amplified on channels 24-26, respectively, on the SCXI-1581 terminal block and then "jumped" to the corresponding channels on the SCXI-1102 terminal block where resistance is measured. The heat flow wires 12-23 (white/black) for each heat flow disk are connected to channels 12-23 on the SCXI-1102 terminal block. Measures of voltage are taken directly from this module (see Figures 12 and 13).

Therefore, connection to the system involves attaching the "male-end" of the harness to the "female-end" of the Deutsch connectors. There are five connections to be made: (1) upper body heat flow disks (2) lower body heat flow disks (3) T_{es} probe (4) T_{re} probe and (5) T_a probe.

User interface design

The front panel (Figure 9) of the program will display skin temperatures, esophageal and rectal temperature in 2-D graphical form (temperature versus time) showing tracings for the entire course of the experiment, as well as numerical form, both in real-time and in a

historical tabular format. T_{sk} will be plotted on one graph, and T_{re} and T_{es} will be plotted together on another.

The front panel will also contain buttons to initiate data recording, cease data recording, and to mark events. In addition, the front panel will have input boxes for entry of alphanumeric characters that will also be written to a spreadsheet.

Air temperature and calculated mean weighted skin temperature will be displayed numerically in real-time and historical tabular format (Figure 9).

As previously mentioned, a log of collected data (in tabular format) will be visible, displaying the last four samples acquired. The table is modified so that the top-most row of data is the most current and incoming data will append to the file.

The intention of the project was that the entire program be written as an executable (.exe) file to avoid manipulation/corruption of the backside code. As of the time of this document, software version issues have prevented us from doing this.

Data security/validation

The system is designed to acquire samples at 15-second intervals, with the user-option to monitor (without recording) or record/write data in ASCII format to disk (C:\unique_filename.txt) immediately after acquiring the sample. Thus, if the system/equipment were to fail during a test, data will still be recoverable up to the failure point, given the data file has not been corrupted. In addition, the system will time-stamp each sample (HH:MM:SS) and record a user-selectable event marker to identify phases of testing. Subject ID number will also be entered by the user to assist in identifying test results when analyzing data at a later point.

EQUATIONS

Steinhart and Hart Thermistor Linearization Equation:

$$T = 1/(0.001462064 + 0.000239335 * \ln(R) + 0.000000096 * (\ln(R))^{**}3) - 273.15$$

Mean Weighted Skin Temperature Equation:

$$MWST = T_{\_forearm}\,(0.07) + T_{\_triceps}\,(0.07) + T_{\_pectoral}\,(0.14) + T_{\_hand}\,(0.07) + T_{\_subscapular}\,(0.14) + T_{\_thigh}\,(0.28) + T_{\_calf}\,(0.17) + T_{\_foot}\,(0.06)$$

TABLES/FIGURES

Table 1: SCXI 1102 Analog Input Module with SCXI 1300 Terminal Block

Channel	Measurement	Terminal	Wire color	Connector and Pin #
0	T_fa	+	purple	M26Deutsch1 C
		-	white/gray	M26Deutsch1 D
1	T_tri	+	white/blue	M26Deutsch1 G
		-	brown	M26Deutsch1 H
2	T_pect	+	white/red	M26Deutsch1 L
		-	white/green	M26Deutsch1 M
3	T_head	+	tan	M26Deutsch1 R
		-	yellow	M26Deutsch1 S
4	T_hand	+	pink	M26Deutsch1 V
		-	gray	M26Deutsch1 W
5	T_subsc	+	purple	M26Deutsch2 C
		-	white/gray	M26Deutsch2 D
6	T_abd	+	white/blue	M26Deutsch2 G
		-	brown	M26Deutsch2 H
7	T_thigh	+	white/red	M26Deutsch2 L
		-	white/green	M26Deutsch2 M
8	T_calf	+	tan	M26Deutsch2 R
		-	yellow	M26Deutsch2 S
9	T_foot	+	pink	M26Deutsch2 V
		-	gray	M26Deutsch2 W
10	T_finger	+	red/black	M26Deutsch1 Z
		-	red	M26Deutsch1 a
11	T_spare	+	red/black	M26Deutsch2 Z
		-	red	M26Deutsch2 a
12	HF_fa	+	white/brown	M26Deutsch1 A
		-	white/yellow	M26Deutsch1 B
13	HF _tri	+	red/green	M26Deutsch1 E
		-	red/yellow	M26Deutsch1 F
14	HF _pect	+	white/black	M26Deutsch1 J
		-	green	M26Deutsch1 K
15	HF _head	+	white/black/red	M26Deutsch1 N
		-	white/purple	M26Deutsch1 P
16	HF _hand	+	orange	M26Deutsch1 T
		-	black	M26Deutsch1 U
17	HF _subsc	+	white/brown	M26Deutsch2 A
		-	white/yellow	M26Deutsch2 B
18	HF _abd	+	red/green	M26Deutsch2 E
		-	red/yellow	M26Deutsch2 F
19	HF _thigh	+	white/black	M26Deutsch2 J
		-	green	M26Deutsch2 K
20	HF _calf	+	white/black/red	M26Deutsch2 N
		-	white/purple	M26Deutsch2 P
21	HF _foot	+	orange	M26Deutsch2 T
		-	black	M26Deutsch2 U
22	HF_finger	+	white/orange	M26Deutsch1 X
		-	blue	M26Deutsch1 Y
23	HF_spare	+	white/orange	M26Deutsch2 X
		-	blue	M26Deutsch2 Y
24	Tc	+		M3Deutsch3 a
		-		M3Deutsch3 c
25	Tes	+		M3Deutsch4 a
		-		M3Deutsch4 c
26	Ta	+		M3Deutsch5 a
		-		M3Deutsch5 c

Table 2: Transducer Wiring				
Measurement	**Sensor**	**Scaling factor**	**Wire color**	**Connector and Pin #**
T_fa	1822	Steinhart and Hart equation	red	F26Deutsch1 C
			yellow	F26Deutsch1 D
T_tri	1834	Steinhart and Hart equation	red	F26Deutsch1 G
			yellow	F26Deutsch1 H
T_pect	1832	Steinhart and Hart equation	red	F26Deutsch1 L
			yellow	F26Deutsch1 M
T_head	1823	Steinhart and Hart equation	red	F26Deutsch1 R
			yellow	F26Deutsch1 S
T_hand	1840	Steinhart and Hart equation	red	F26Deutsch1 V
			yellow	F26Deutsch1 W
T_subsc	1826	Steinhart and Hart equation	red	F26Deutsch2 C
			yellow	F26Deutsch2 D
T_abd	1829	Steinhart and Hart equation	red	F26Deutsch2 G
			yellow	F26Deutsch2 H
T_thigh	1838	Steinhart and Hart equation	red	F26Deutsch2 L
			yellow	F26Deutsch2 M
T_calf	1835	Steinhart and Hart equation	red	F26Deutsch2 R
			yellow	F26Deutsch2 S
T_foot	1839	Steinhart and Hart equation	red	F26Deutsch2 V
			yellow	F26Deutsch2 W
T_finger	1018	Steinhart and Hart equation	red	F26Deutsch1 Z
			yellow	F26Deutsch1 a
T_spare	1021	Steinhart and Hart equation	red	F26Deutsch2 Z
			yellow	F26Deutsch2 a
HF_fa	1822	54970	white	F26Deutsch1 A
			black	F26Deutsch1 B
HF _tri	1834	55140	white	F26Deutsch1 E
			black	F26Deutsch1 F
HF _pect	1832	55790	white	F26Deutsch1 J
			black	F26Deutsch1 K
HF _head	1823	55810	white	F26Deutsch1 N
			black	F26Deutsch1 P
HF _hand	1840	56540	white	F26Deutsch1 T
			black	F26Deutsch1 U
HF _subsc	1826	56600	white	F26Deutsch2 A
			black	F26Deutsch2 B
HF _abd	1829	56660	white	F26Deutsch2 E
			black	F26Deutsch2 F
HF _thigh	1838	57950	white	F26Deutsch2 J
			black	F26Deutsch2 K
HF _calf	1835	58520	white	F26Deutsch2 N
			black	F26Deutsch2 P
HF _foot	1839	58630	white	F26Deutsch2 T
			black	F26Deutsch2 U
HF_finger	1018	136570	white	F26Deutsch1 X
			black	F26Deutsch1 Y
HF_spare	1021	136570	white	F26Deutsch2 X
			black	F26Deutsch2 Y
Tc	YSI 44000 series	Steinhart and Hart equation	black	F3Deutsch3 a
			red	F3Deutsch3 c
Tes	YSI 44000 series	Steinhart and Hart equation	gray	F3Deutsch4 a
			gray	F3Deutsch4 c
Ta	YSI 44000 series	Steinhart and Hart equation	black	F3Deutsch5 a
			red	F3Deutsch5 c

Table 3: Spreadsheet Labeling Scheme	
Column	Label
1	*ID*
2	*Hour*
3	*Min*
4	*Sec*
5	*ET*
6	*T_fa*
7	*T_tri*
8	*T_pect*
9	*T_head*
10	*T_hand*
11	*T_subsc*
12	*T_abd*
13	*T_thigh*
14	*T_calf*
15	*T_foot*
16	*T_finger*
17	*T_spare*
18	*MWST*
19	*HF_fa*
20	*HF_tri*
21	*HF_pect*
22	*HF_head*
23	*HF_hand*
24	*HF_subsc*
25	*HF_abd*
26	*HF_thigh*
27	*HF_calf*
28	*HF_foot*
29	*HF_finger*
30	*HF_spare*
31	*Tc*
32	*Tes*
33	*Ta*
34	*Event*

Figure 1: Get Current Time VI

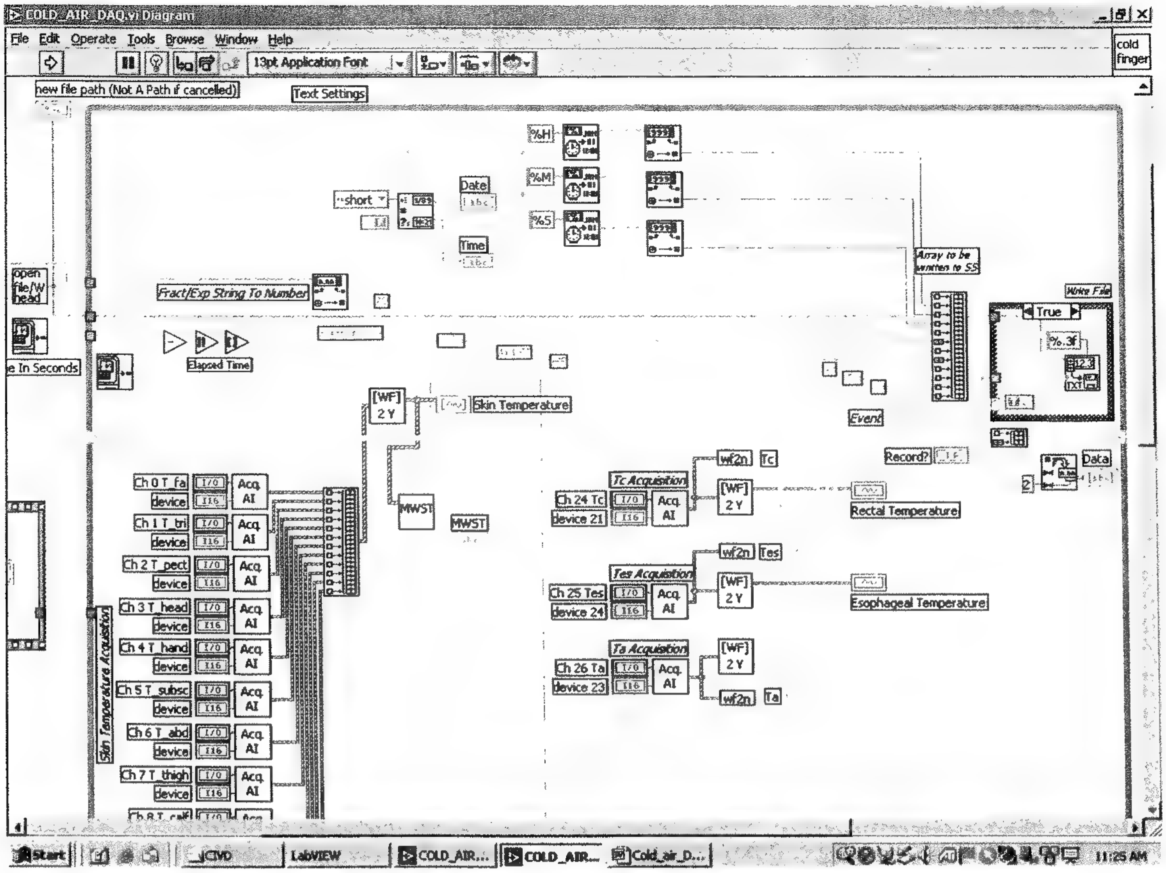


Figure 2: Build Header VI

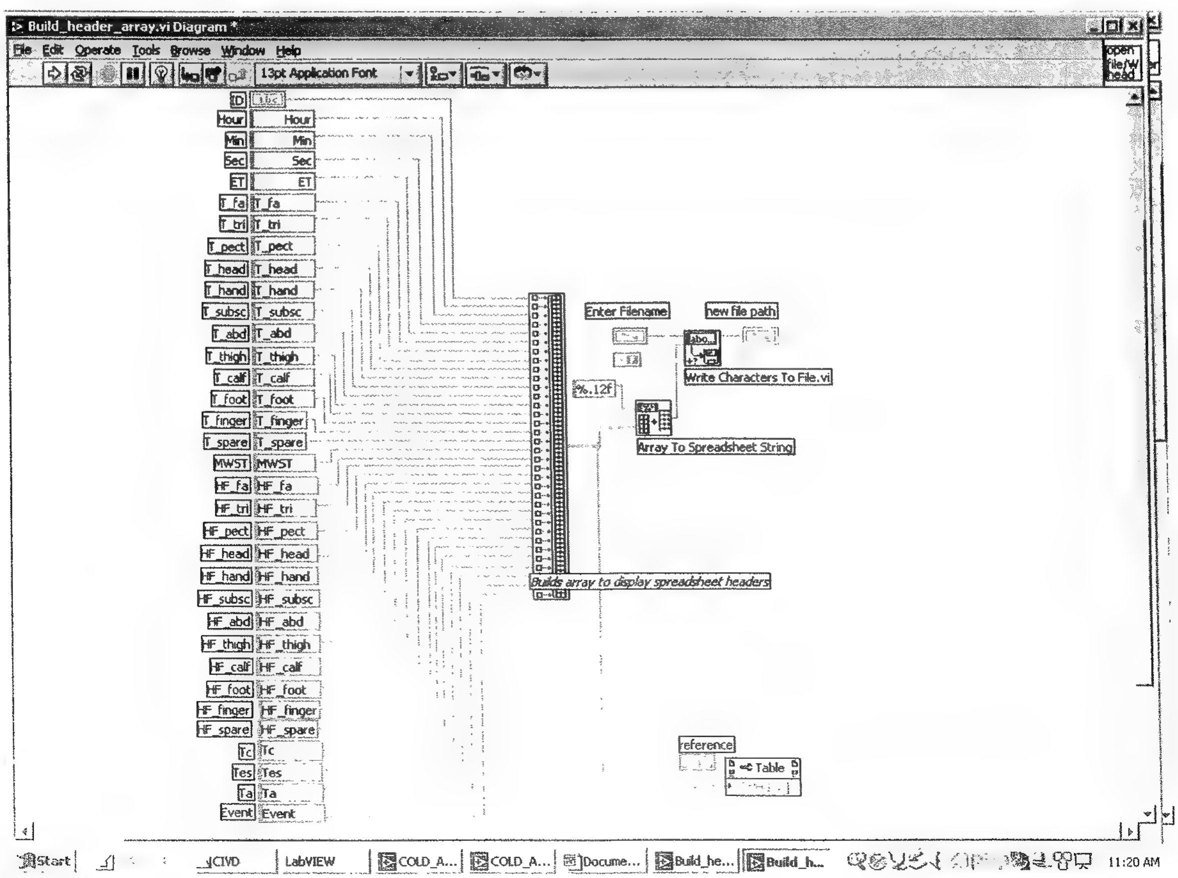


Figure 3: Acquire Analog Input VI

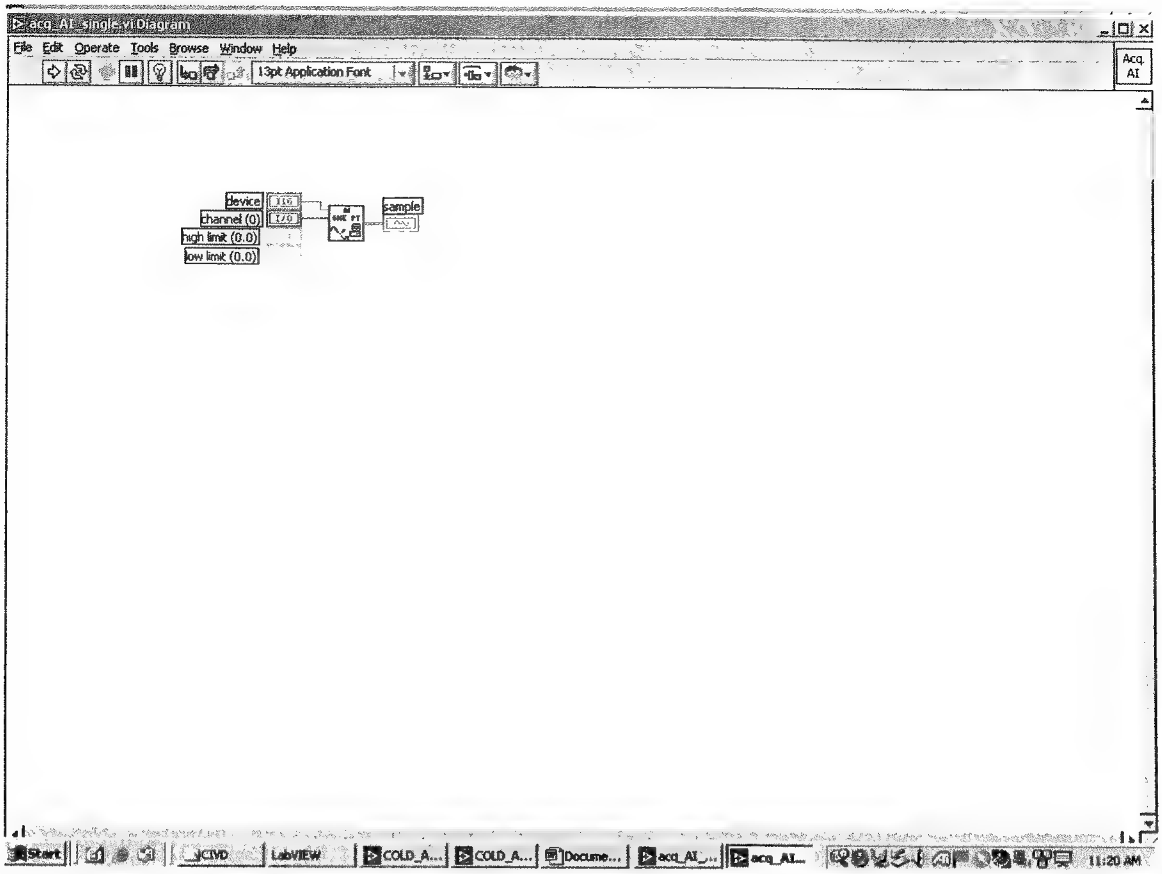


Figure 4: Waveforms to Y VI

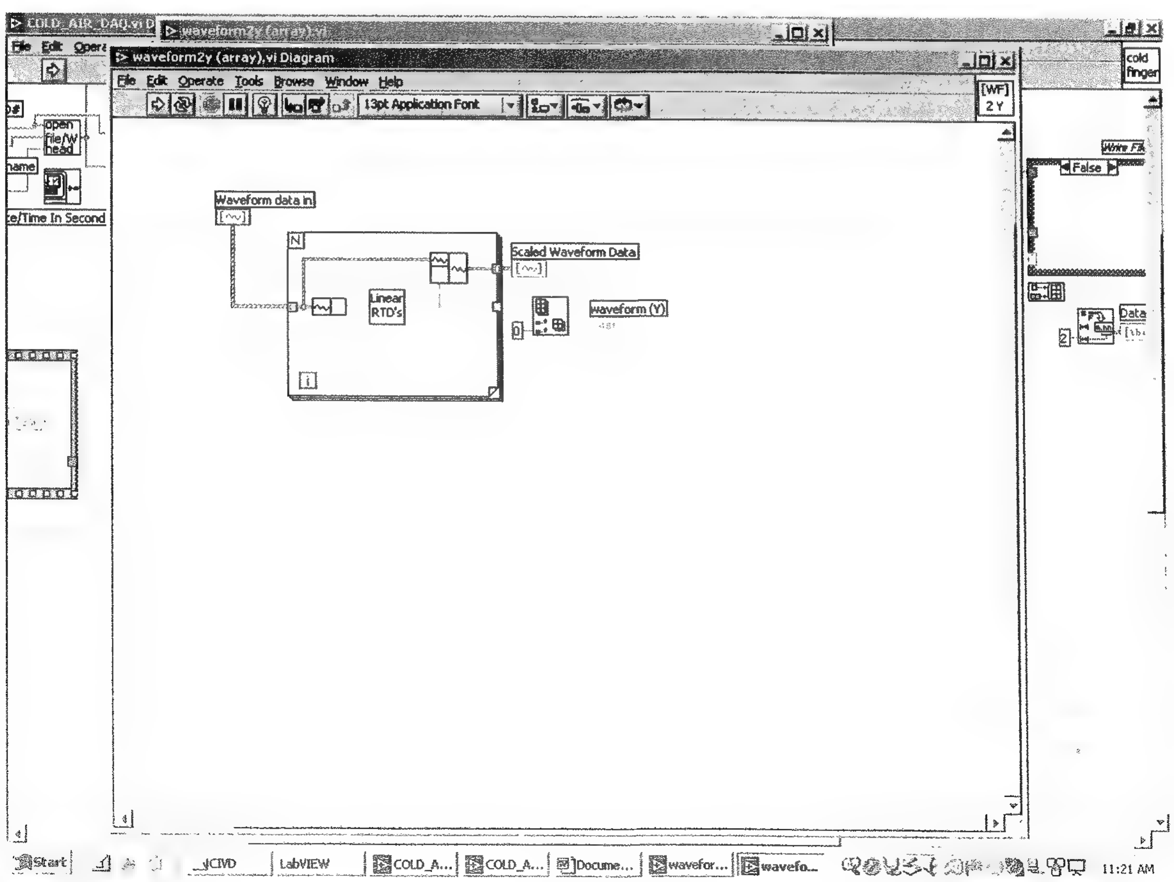


Figure 5: Linearize THMs VI

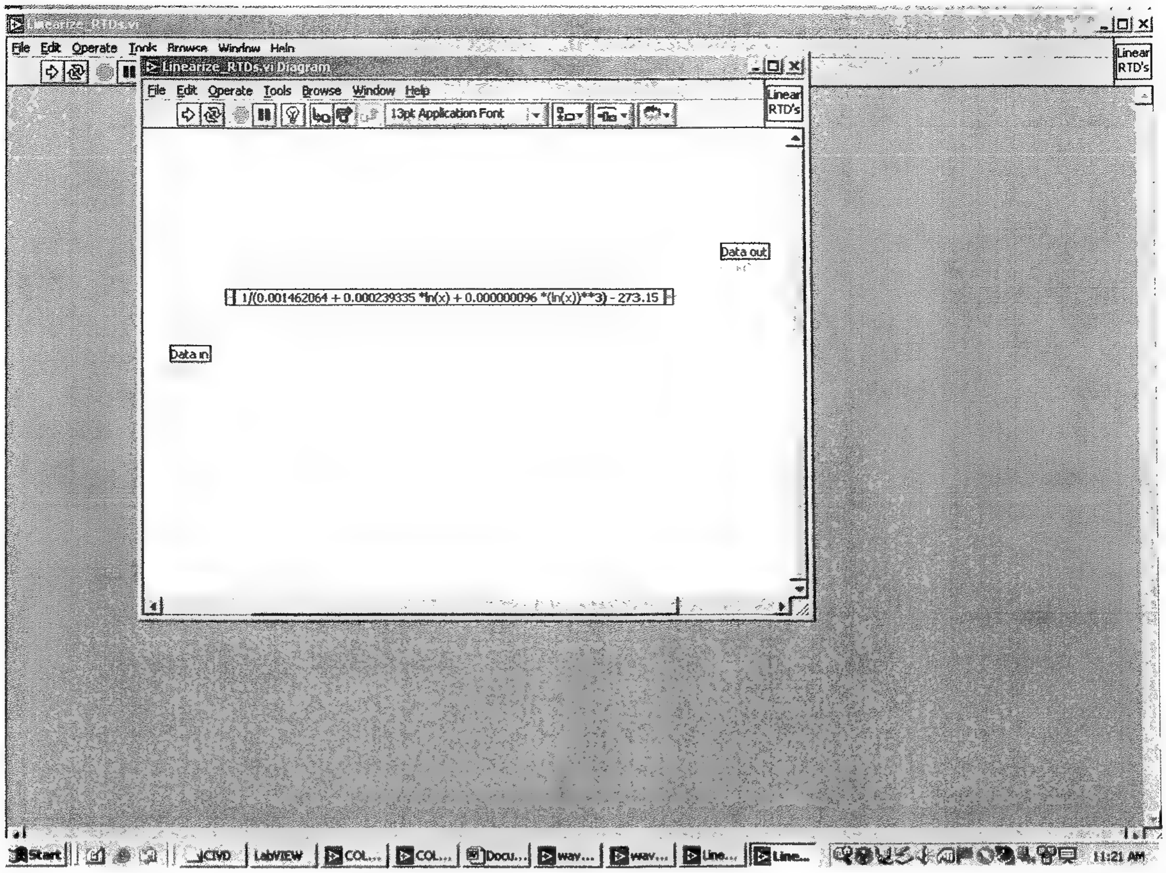


Figure 6: Scale Heat Flows VI

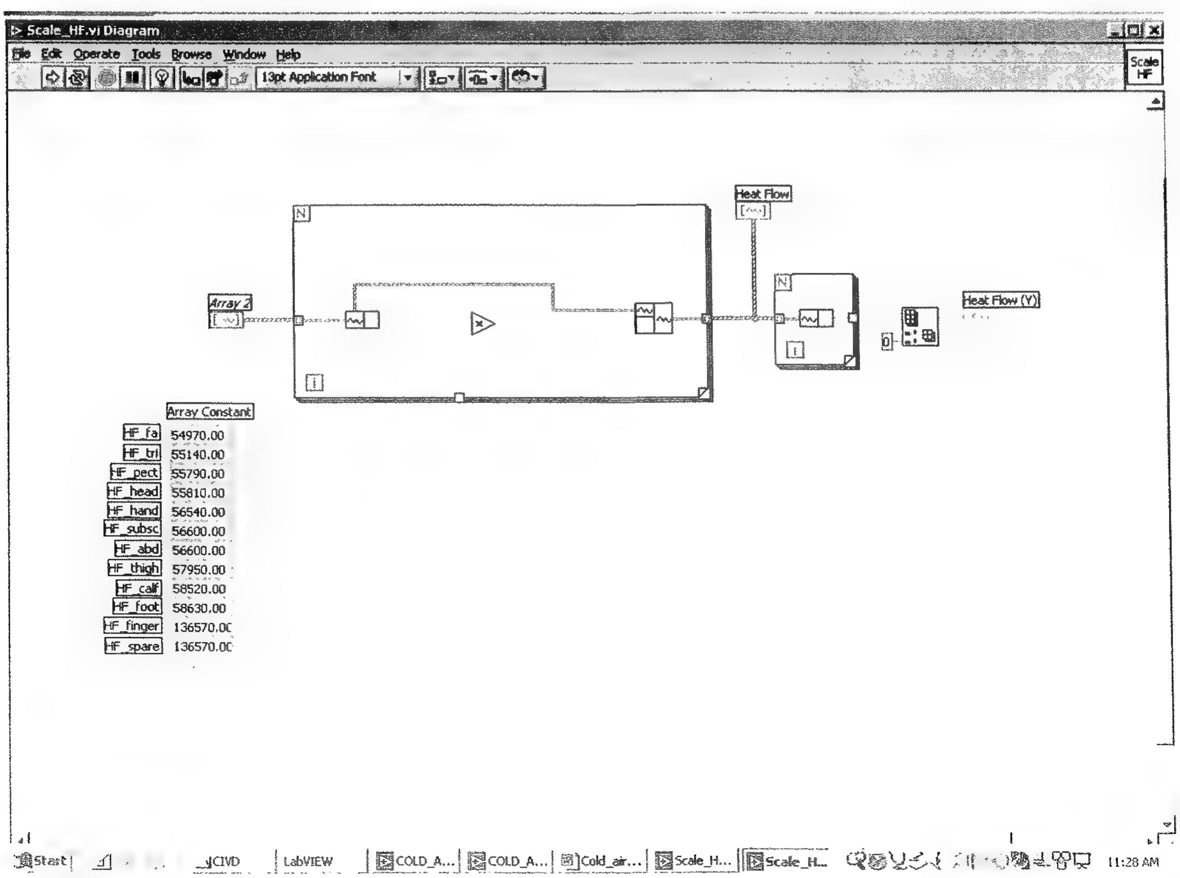


Figure 7: Cold Air DAQ VI (upper left view)

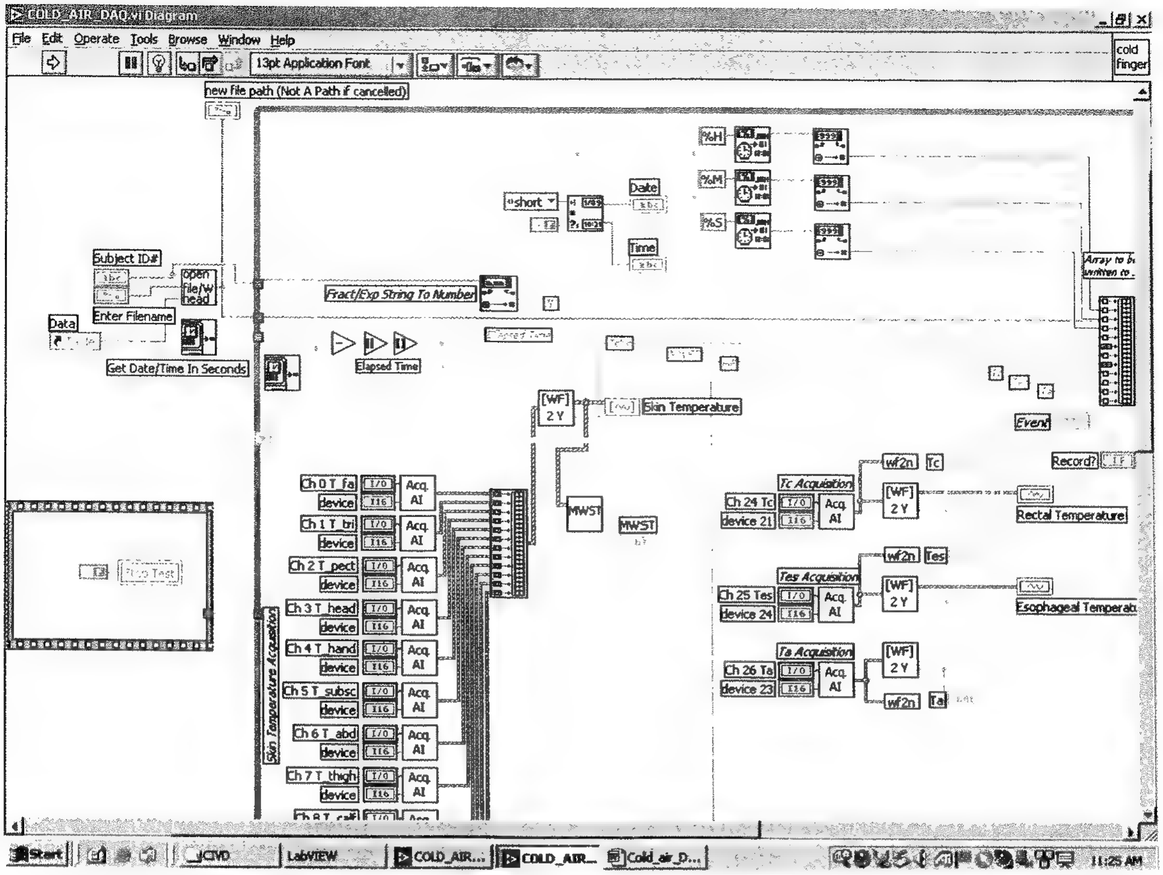


Figure 8: Cold Air DAQ VI (lower left view)

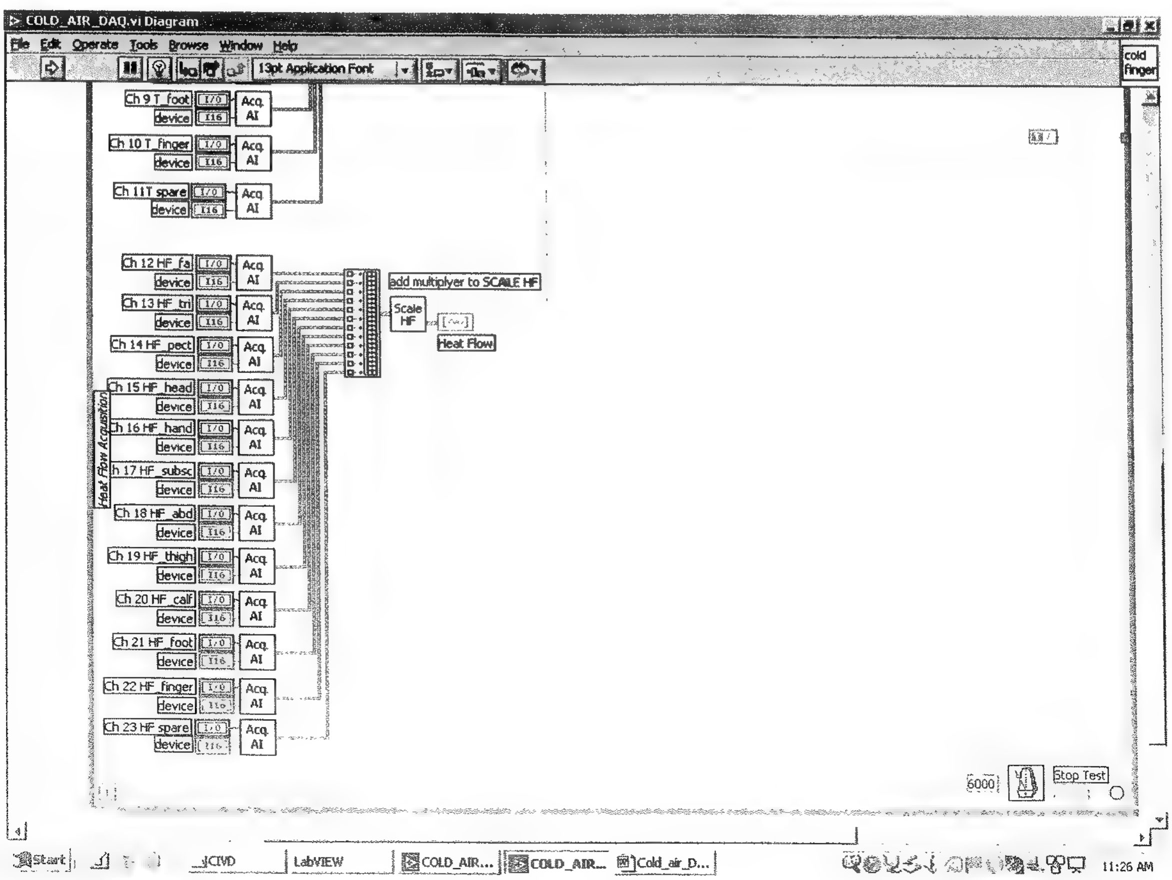


Figure 9: Cold Air DAQ VI (Front Panel)

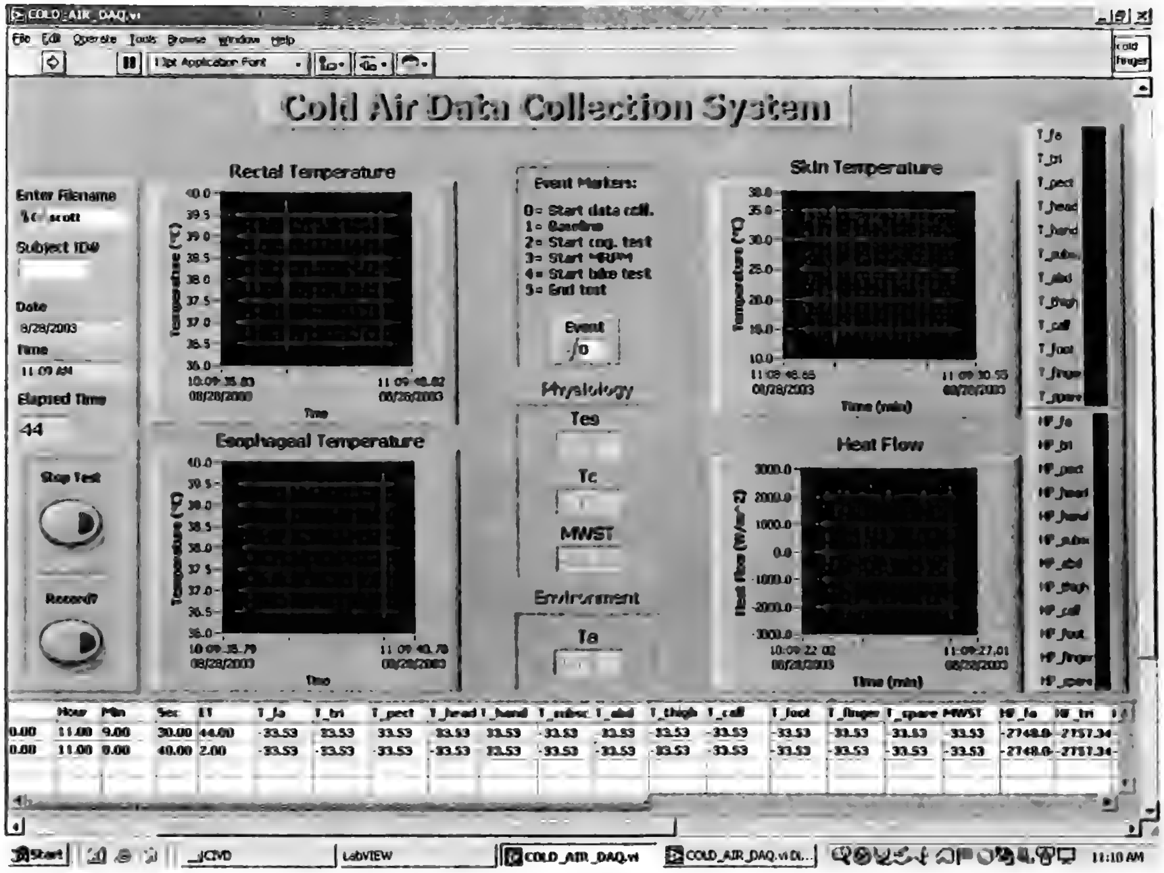


Figure 10: Cold Air DAQ VI (Channel Selectors)

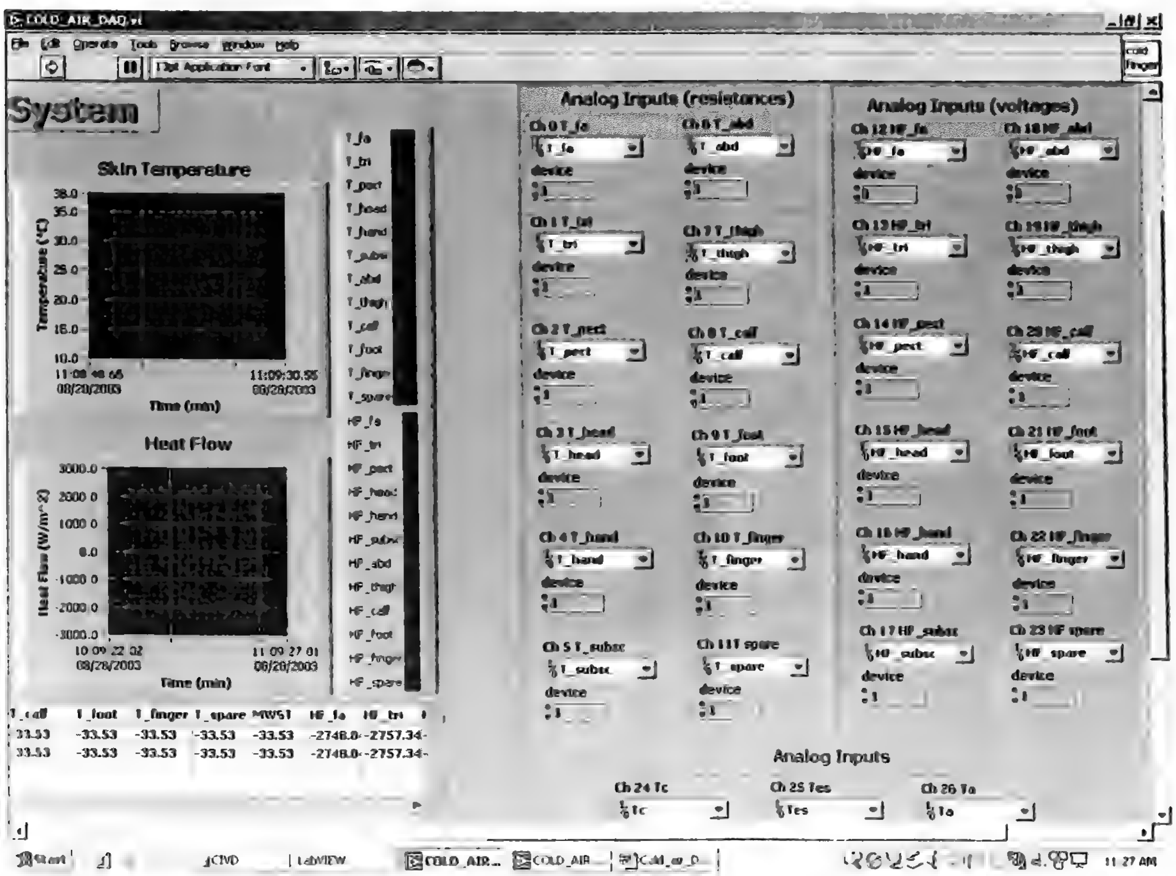
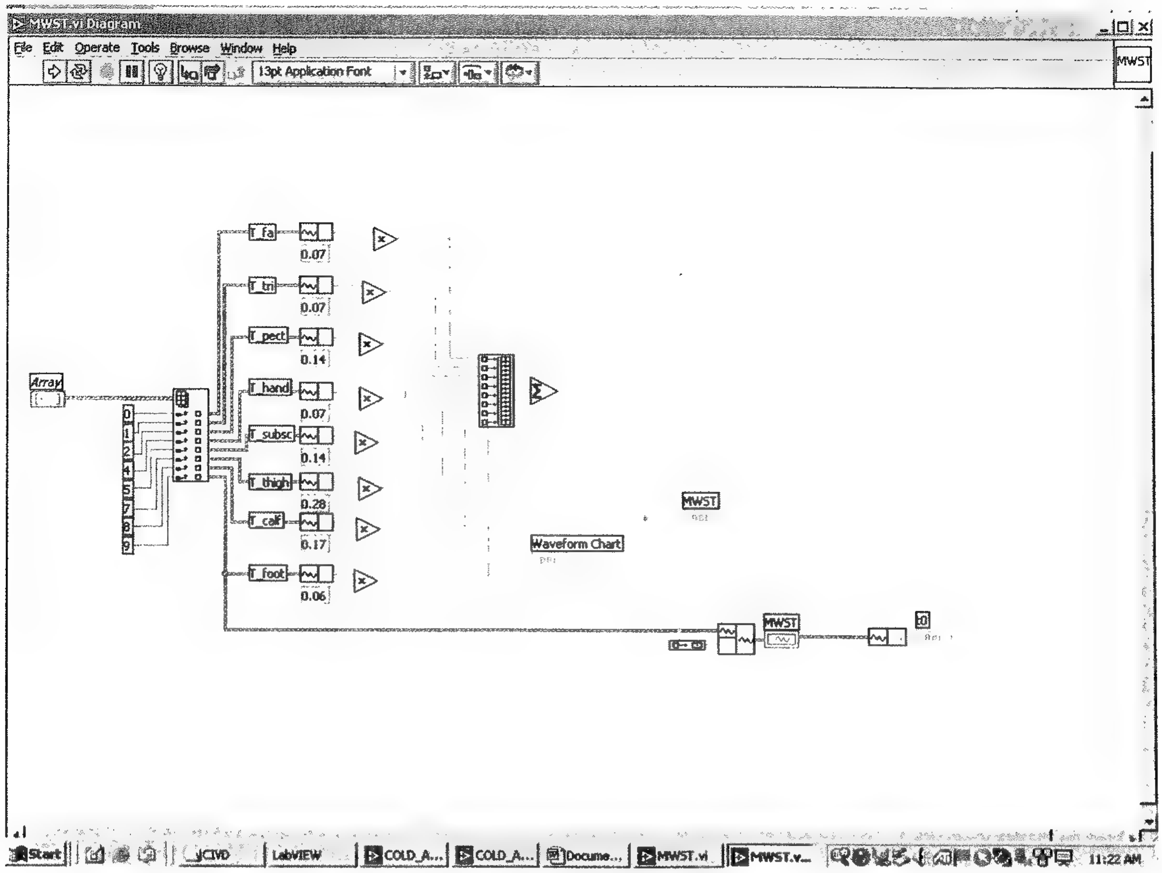


Figure 11: Mean Weighted Skin Temperature (MWST) VI



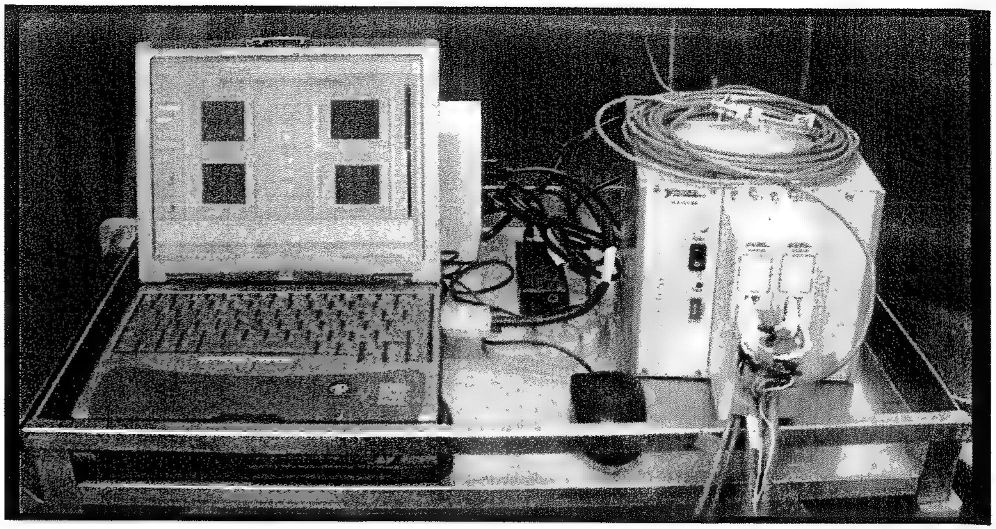


Figure 12:
Entire Cold Air DAQ System

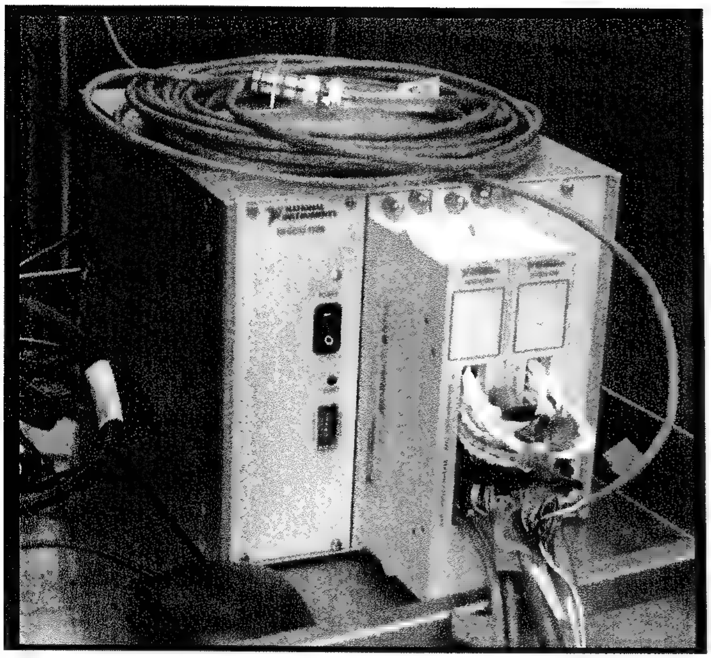


Figure 13:
SCXI-1000 Chassis with SCXI-1581 (L) and SCXI-1102 (R) modules each connected to a SCXI-1300 terminal block

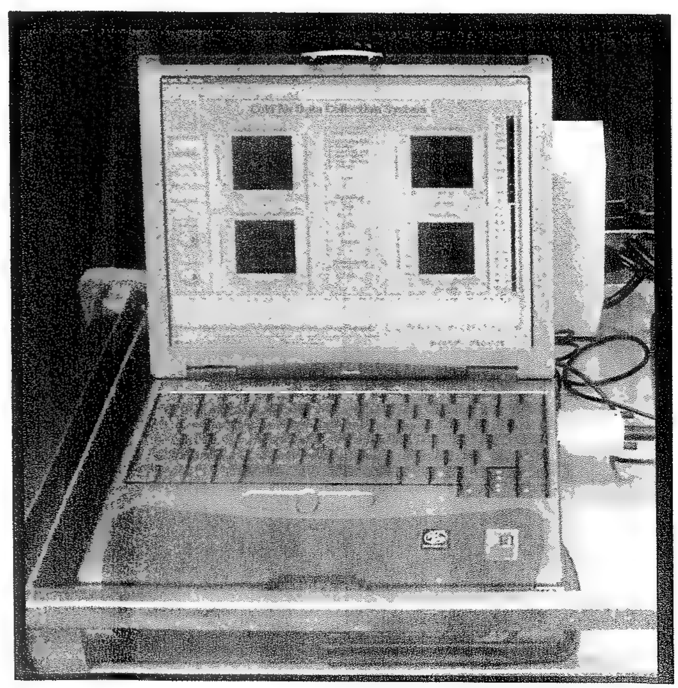
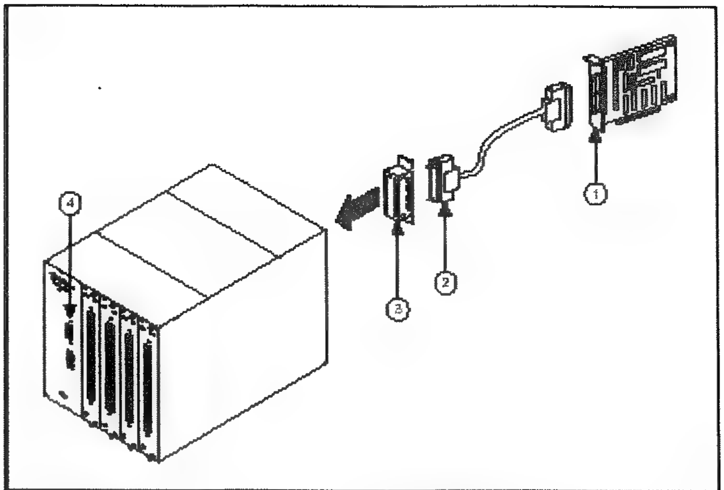
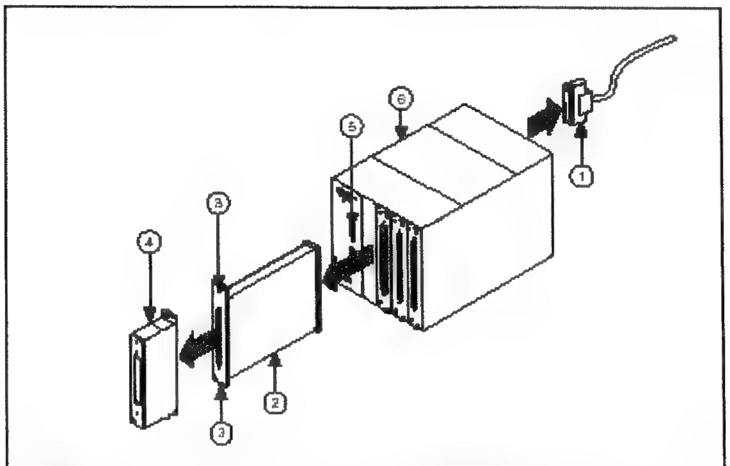


Figure 14:
Laptop running LabVIEW 6.0

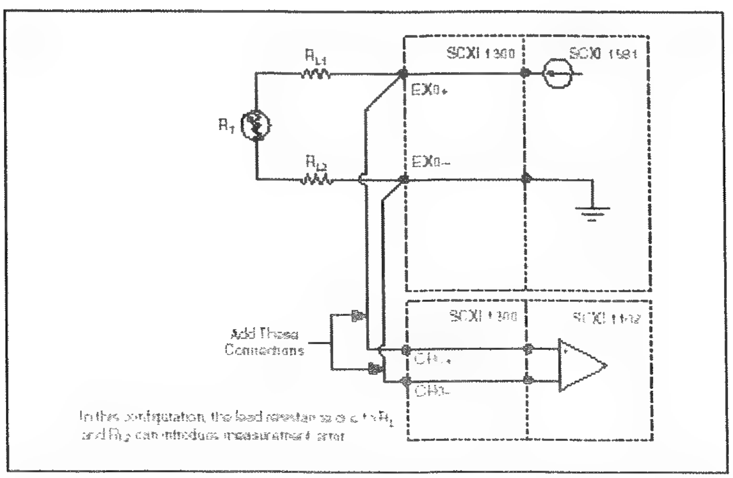
DIAGRAMS

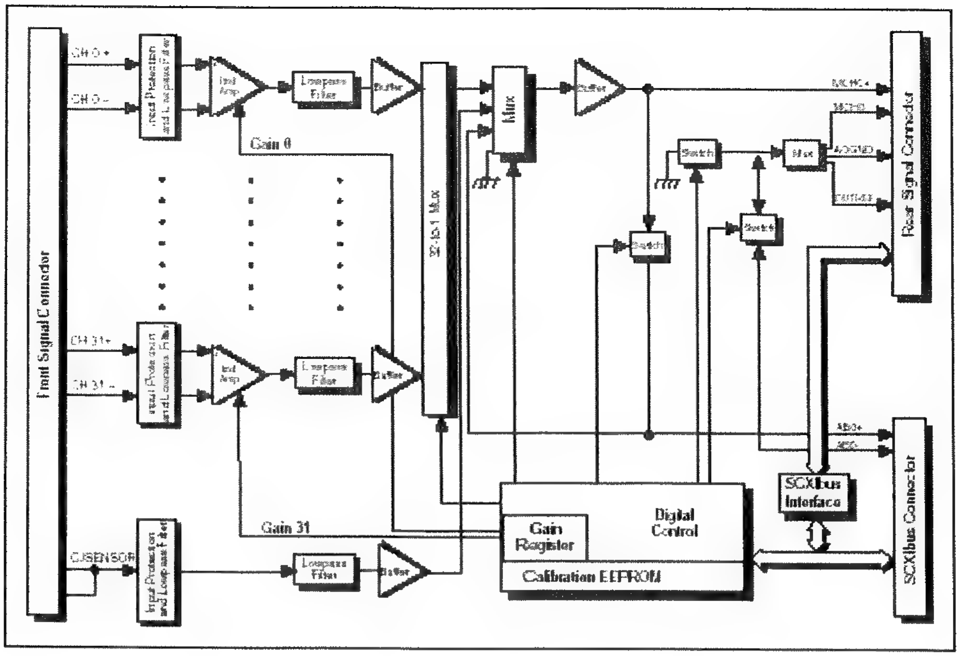


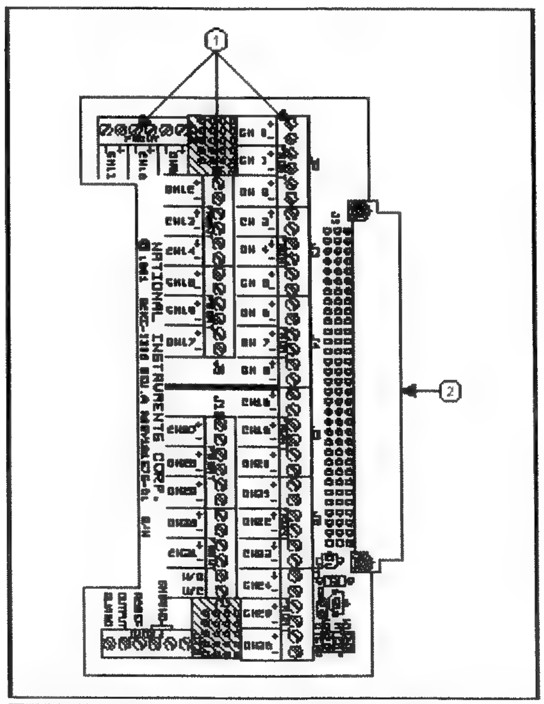
1	E Series DAQ Device	3	Cable Adapter
2	SH68-68 Cable	4	SCXI Chassis Power Switch



1	Cable	4	Terminal Block
2	SCXI-1591	5	SCXI Chassis Power Switch
3	SCXI Module Thumbscrews	6	SCXI Chassis







1 Screw Terminals 2 Mating Connector

COMPONENT SPECIFICATIONS

SCXI-1000

Electrical

Supplies	SCXI-1000/ 1000DC/2000	SCXI-1001
V+		
Tolerance limits include peaks	+18.5 to +25 V	–18.5 to –25 V
Ripple (peak-to-peak)	1.5 V	1.5 V
Max load	680 mA	2.04 A
V–		
Tolerance limits include peaks	–18.5 to –25 V	–18.5 to –25 V
Ripple (peak-to-peak)	1.5 V	1.5 V
Max load	680 mA	2.04 A
+5 V		
Tolerance limits include peaks	+4.75 to +5.25 V	+4.75 to +5.25 V
Ripple (peak-to-peak)	50 mV	50 mV
Max load	250 mA	600 mA

Maximum loads are the supply current for the entire chassis. Scaling the maximum power gives the allotted current per slot, as follows:

Supplies	SCXI-1000/ 1000DC/2000	SCXI-1001
V+	170 mA	170 mA
V–	170 mA	170 mA
+5 V	50 mA	170 mA

Source Power Requirements

Line Voltage, 47–63 Hz	Max AC Current		
	SCXI-1000	SCXI-1001	SCXI-2000
120 VAC, ± 10%	0.6 A	1.25 A	0.6 A
100 VAC, ± 10%	0.5 A	1.25 A	0.5 A
240 VAC, ± 10%	0.25 A	0.75 A	0.25 A
220 VAC, ± 10%	0.25 A	0.75 A	0.25 A

SCXI-1000DC

Input voltage ....12 VDC nominal
(9.5 to 16.0 VDC)
Max DC operating current
at 9.5 VDC...5.5 A

Physical

Weight
SCXI-1000...3.9 kg (8 lb 10 oz)
SCXI-1000DC ....3.3 kg (7 lb 5 oz)
SCXI-1001...6.8 kg (14 lb 14 oz)
SCXI-2000...3.8 kg (8 lb 8 oz)
Refer to the following figures for the physical dimensions of the 4-slot chassis (SCXI-1000, SCXI-1000DC, and SCXI-2000) and the 12-slot

chassis (SCXI-1001).

Environment

Operating temperature ....0° - 50°C
Storage temperature ....-20° - 70 °C
Relative humidity ....5% - 90% non-condensing

SCXI-1102

Analog Input

Input Characteristics
Number of channels .... 32 differential
Input signal ranges .... ±100 mV (gain = 100) or ±10 V (gain = 1)
Max working voltage (signal + common mode) ....Each input should remain within ±10 V
Input damage level .... ±42 V
Inputs protected .... CH<0.31>, CJSENSOR

Transfer Characteristics
Nonlinearity .... 0.005% FSR
Offset error
Gain = 1
After calibration .... 150 μV max
Before calibration.. 600 μV
Gain = 100
After calibration .... 15 μV max
Before calibration.. 100 μV
Gain error (relative to calibration reference)
Gain = 1
After calibration .... 0.015% of reading max
Before calibration.. 0.04% of reading
Gain = 100
After calibration .... 0.017% of reading max
Before calibration.. 0.1% of reading

Amplifier Characteristics
Input impedance
Normal powered on... > 1 GΩ
Powered off .... 10 kΩ
Overload.. 10 kΩ
Input bias current .... ±0.5 nA
Input offset current .... ±1.0 nA
CMRR
50 to 60 Hz, either gain .... 110 dB
0 Hz, gain 1 .... 75 dB min
0 Hz, gain 100 .... 100 dB min
Output range .... ±10 V
Output impedance .... 91 Ω

Dynamic Characteristics
Bandwidth .... 1 Hz
Scan interval (per channel, any gain)
0.012%1 .... 3 μs
0.0061%2 .... 10 μs
System noise (related to input) ....
Gain = 1... 50 μVrms

Gain = 100 .... 5 μVrms

Filters
Cutoff frequency (-3 dB) .... 1 Hz
NMR (60 Hz) .... 40 dB
Step response (either gain)
To 0.1% .... 1 s
To 0.01% .... 10 s

Stability
Recommended warm-up time .... 20 min.
Offset temperature coefficient
Gain = 1 .... 20 μV/°C
Gain = 100 .... 1 μV/°C
Gain temperature coefficient .... 10 ppm/°C

Physical

Dimensions .... 3.0 by 17.2 by 20.3 cm (1.2 by 6.8 by 8.0 in.)
I/O connector .... 50-pin male ribbon cable rear connector
96-pin male DIN C front connector

Environmental

Operating temperature .... 0° - 50°C
Storage temperature .... -55° - 150°C
Relative humidity .... 5% - 90% non-condensing

Specifications

This appendix lists the specifications for the SCXI-1581 modules. These specifications are typical at 25°C unless otherwise noted.

Stability

Recommended warm-up time	10 minutes

Excitation

Channels	32 single-ended outputs
Current output	100 µA
Accuracy	±0.05%
Temperature drift	±5 ppm/°C
Output voltage compliance	10 V
Maximum resistive load	100 k̃
Overvoltage protection	±40 VDC
Installation Category	I

Power Requirements From SCXI Backplane

V+	18.5 - 25 VDC, 75 mA
V–	-18.5 - -25 VDC, 23 mA
+5 V	+4.75 - 5.25 VDC, 20.2 mA

Environmental

Operating temperature	0° - 50 °C
Storage temperature	-20° - 70 °C
Humidity	10% - 90% RH, non-condensing
Maximum altitude	2,000 meters
Pollution Degree (indoor use only)	2

Physical

Dimensions	3.0 by 17.2 by 20.3 cm

(1.2 by 6.9 by 8.0 in.)

Safety

The SCXI-1581 meets the requirements of the following standards for safety and electrical equipment for measurement, control, and laboratory use:

- IEC 61010-1, EN 61010-1
- UL 3111-1, UL 61010B-1
- CAN/CSA C22.2 No. 1010.1

SCXI-1300

Electrical

(Cold-Junction Sensor on the SCXI-1300)

Sensor type.. Integrated circuit (LM35CAZ)
Accuracy1 .... ± 1.3°C from 0° - 50 °C
Repeatability .... ± 0.5°C
Output.. 0 - 0.5 V from 0° - 50 °C (10 mV/°C)

Environmental

Operating temperature............................ 0° - 50°C
Storage temperature .... -20° - 70°C
Relative humidity.................................... 10% - 90%
Indoor use only

KNOWN SYSTEM ISSUES

The fact that this system has been designed to run off a laptop computer poses some known issues. The software has to initialize its analog input acquisition devices only one time at the beginning of testing. According to one of our LabVIEW consultants, this may take anywhere from 250 ms to 1000 ms per device. Our testing has shown that this produces a "lag-time" of ~36-42 seconds. Therefore, our first sample will not be able to be acquired until ~40 seconds. The system does, however, timestamp the sample correctly despite the brief loss of data. There has not been any loss of data or slowing of acquisition or system resources following the first initialization. A "popup" screen (saying "Initializing Instruments...Please wait...") is activated when the user presses the "run" button. The popup will remain up as long as the VIs are still initializing.

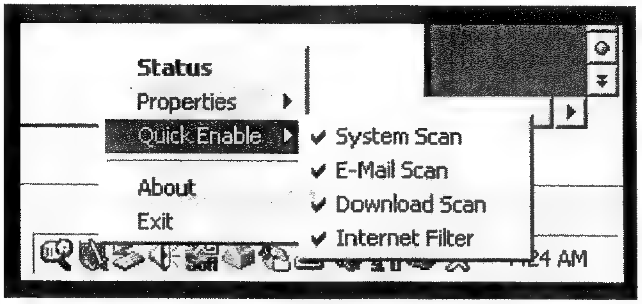
It is also recommended that all non-essential system resources (including virus scans, screen savers, and energy savers) be temporarily disabled to free up some load on the processor.

1. Turn on UPS power switch.

2. Turn on SCXI chassis power switch.

3. Turn on laptop computer (**Password:** **********).

4. Disable <u>all</u> McAfee scans. Right click on the McAfee icon on the lower MS toolbar. Move over "quick enable", and click on all items with a check mark to the left of it. Ensure that no items have a check mark next to it.



5. Disable <u>all</u> screen savers and power managers.

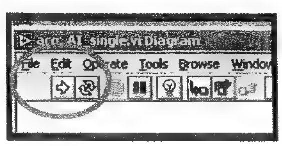
6. Launch Cold_Air_DAQ.vi application from desktop shortcut. Program is located on C:\.

7. Maximize window.

8. Enter unique filename.

9. Enter two-digit subject number (e.g. 01, 02, 13).

10. Press "run" button (located on navigation bar) when ready to monitor data. (Note: data are being monitored but not recorded. The "record" button must be pressed to acquire data.)



11. Press "record" button to record data to spreadsheet.

12. Toggle the "Event Marker" control to record different phases of testing during experiment.

13. Press "stop" button to end both monitoring and recording.

14. Find file C:\your_unique_filename.txt and copy to Zip disk.

15. Close program, shutdown laptop, and then turn off power on SCXI chassis.

REFERENCES

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2. National Instruments Corporation. *National Instruments DAQ SCXI-1000 User Manual.* Austin, TX: 2000.

3. National Instruments Corporation. *National Instruments DAQ SCXI-1102/B/C User Manual.* Austin, TX: 1997.

4. National Instruments Corporation. *National Instruments DAQ SCXI-1300 User Manual.* Austin, TX: 2001.

5. National Instruments Corporation. *National Instruments DAQ SCXI-1581 User Manual.* Austin, TX: 2002.

6. National Instruments Corporation. *National Instruments LabVIEW 6.1 Developers Suite.* Austin, TX: 2002.

7. National Instruments Corporation. *National Instruments LabVIEW Basics I and II Development course Manual.* Austin, TX: 2002.

8. National Instruments Corporation. *National Instruments LabVIEW Measurements Manual.* Austin, TX: 2000.

9. National Instruments Corporation. *National Instruments Measurement and Automation Catalog 2003.* Austin, TX: 2003.

SYMBOLS/ACRONYMS/ABBREVIATIONS

Ω	Ohms (resistance)
°C	Degrees Celcius
μA	Microamps
μV	Microvolts
A	Amps
AC	Alternating current
A/D	Analog to digital
Acq. AI	Acquire Analog Input
ASCII	American Standard Code for Information Interchange
CPU	Central processing unit
D/A	Digital to analog
DAQ	Data acquisition
DC	Direct current
ET	Elapsed Time
exe	Executable file (stand alone PC-compatible application)
GUI	Graphical user interface
HF	Heat flow
HF _abd	Abdominal heat flow
HF _calf	Calf heat flow
HF _fa	Forearm heat flow
HF _finger	Finger heat flow
HF _foot	Foot heat flow
HF _hand	Hand heat flow
HF _head	Head heat flow
HF _pect	Pectoral (chest) heat flow

HF _spare	Spare heat flow
HF _subsc	Subscapular (back) heat flow
HF _thigh	Thigh heat flow
HF_tri	Triceps heat flow
ln	Natural log
mA	Milliamps
ms	Milliseconds
mV	Millivolts
MAX	Measurement and Automation Explorer
MWST	Mean Weighted Skin Temperature
NI	National Instruments
PCMCIA	Personal Computer Memory Card International Association
RH	Relative humidity
SCXI	Signal Conditioning extensions for Instrumentation
SOP	Standard Operating Procedure
T_abd	Abdominal temperature
T_calf	Calf temperature
T_fa	Forearm temperature
T_finger	Finger temperature
T_foot	Foot temperature
T_hand	Hand temperature
T_head	Head temperature
T_pect	Pectoral (chest) temperature
T_spare	Spare temperature
T_subsc	Subscapular (back) temperature

T_thigh	Thigh temperature
T_tri	Triceps temperature
Ta	Ambient temperature
Tes	Esophageal temperature
Tre	Rectal temperature
Tsk	Skin temperature
V	Volts or voltage
VI	Virtual Instrument